SP-E4 Flood Management Study

October 25, 2002

1.0 Introduction/Background

Flood management is one benefit that was delivered by Oroville Dam even before it was complete. While the dam was under construction, it prevented millions of dollars of property damage and saved lives by impounding the floodwaters in 1964. Today, flood management remains one of the major benefits of this dam.

Flood management is essential for the health, safety and economy of the area exposed to such hazards. Even after the construction of Oroville facilities, areas along Yuba River, and Feather River (downstream of Oroville dam) have experienced major floods several times such as in 1986 and in 1997.

Since the construction of Oroville Facilities in 1967, land use changes in the downstream area and changes in technology have occurred:

- Natural growth over time has increased both the extent and the intensity of development in the Feather River and Yuba River flood plains. Both of these factors contribute to increased impact of floods.

- Significant advances have been made in:

    - The collection/application of real-time data for forecasting reservoir inflow
    - The science of hydrology, topographic, and geographic mapping
    - Computer software used in hydrologic, and flood routing studies
    - The engineering of flood control structures

- Additional water storage facilities have been planned or constructed in the Sacramento and San Joaquin River basins. Operations of these facilities affect flood conditions in the region. Floods are basin-wide and regional problems and require regional, coordinated solutions.

A number of studies performed by other parties are currently underway to review ways to improve flood management for the Sacramento River and its tributaries, including the Feather and Yuba Rivers (see Task 3).

The study would also address specific issues identified in the scoping process.

Flood management operations at Oroville are in accordance with flood control regulations prescribed by the Secretary of the Army. The primary objectives of flood control operation are to:

- Minimize flood damages downstream; and,
- Avoid causing damage that would not have occurred under conditions without the project.

The Standard Project Flood (SPF) at Oroville: The SPF has a peak flow of 440,000 cfs and a 72-hour volume of 1,520,000 acre-feet, and is estimated to inundate close to 292,000 acres. This standard project flood results from the standard project rainstorm of 96-hour duration depositing 14.3 inches of precipitation on wet ground in the drainage basin above the dam.

The Probable Maximum Flood (PMF) for Oroville Dam: The PMF is based on the Probable Maximum Precipitation (PMP-rain and snow) and is used for spillway design purposes. The US Army Corps of Engineers estimated the PMF in 1970 to have a peak flow of 720,000 cfs and a 72-hour runoff volume of 2,510,000 acre-feet, and results from a 72-hour storm depositing 21.1 inches of precipitation.

The PMF study was updated by USACE in 1980. It showed that the PMF has a peak inflow of 960,000 cfs and an 8-day run-off volume of 5,217,300 acre-feet.

Flood Control Space Requirement: Maximum flood control space requirement for Oroville Reservoir was based primarily on protection of urban and agricultural areas along the Feather River below the reservoir against winter floods up to a magnitude of the standard project flood. Flood control space requirement, determined through planning studies, was set at 750,000 acre-feet.

Release Requirement: The permissible releases were limited to a maximum of 150,000 cfs. Minimum release requirements were mutually agreed between the State of California and the United States. In order to fully utilize downstream channel capacities and flood control space under various flood conditions, a release capability of 150,000 cfs was determined desirable, the State and the US agreed that a smaller release at lower reservoir levels would be acceptable. A release capacity of 75,000 cfs with the reservoir level at the bottom of the flood control storage space, and 150,000 cfs release capacity with the water level at EL 863.5 were agreed to. Subsequent studies indicated that the release capacity of the flood control outlet with the reservoir at EL 848.5 was 85,000 cfs and was used for reservoir regulation purposes.

2.0 Study Objective

The general objective of this study is to document current flood control requirements, analyze flood management under current operations and identify opportunities for future improvements in flood management.

The Flood Management Study, in conjunction with other studies, will:

- Address specific issue(s) identified in the scoping process
- Document current:
    - FERC license requirements with respect to flood management and the resulting project operations.
    - Flood storage capabilities and requirements of project reservoirs
    - Assumptions used to develop current flood storage requirements
    - Policy with regard to level of protection afforded floodplain areas downstream of the hydroelectric project
    - Legal mandates for the project in terms of flood control

    - Communication systems, warning systems, and evacuation requirements currently in place (Oroville Emergency Action Plan)
- Provide
    - Estimated flood profiles between Oroville Dam and the confluence with the Yuba River for the 100-year event.
    - The 100-year floodplain, under current operations, in digital format, using recent topographic mapping information.
    - The Flood Management Study will also investigate opportunities for improvements in flood management including the identification and assessment of Analyses of selected flood control alternatives will be performed. The Flood Management Study will focus on impacts in the study area along the Feather River from Hyatt Powerhouse to the confluence of the Feather River and Yuba River.

- Identify, analyze, and evaluate:
    - Opportunities for increasing efficiency of warning system
    - Potential effects of urbanization and suburban development on flooding
    - Potential effects of alternative reservoir management strategies, flood control operating policies and flood hazard reduction options.
    - Construction of new or alteration of existing flood control structures.
    - Updating the flood analysis studies by using the current information and technology.
    - Coordinated operations among water agencies.

3.0 Relationship to Relicensing /Need for the Study

A comprehensive plan for developing the waterway for the beneficial public use including flood control is required by FERC (18 CFR Subchapter B, Part 4, Paragraph 4.51). Federal Power Act states that flood control benefits of a project and the recommendations of Federal and State agencies exercising administration over flood control would be considered by FERC:

"All licenses issued under this subchapter shall be on the following conditions:

- Modification of plans; factors considered to secure adaptability of project; recommendations for proposed terms and conditions

    - That the project adopted, including the maps, plans, and specifications, shall be such as in the judgment of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water-power development, for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat), and for other beneficial public uses, including irrigation, flood control, water supply, and recreational and other purposes referred to in section 797(e) of this title (FOOTNOTE 1) if necessary in order to secure such plan the Commission shall have authority to require the modification of any project and of the plans and specifications of the project works before approval.

- In order to ensure that the project adopted will be best adapted to the comprehensive plan described in paragraph (1), the Commission shall consider each of the following:

    - The recommendations of Federal and State agencies exercising administration over flood control, navigation, irrigation, recreation, cultural and other relevant resources of the State in which the project is located, and the recommendations (including fish and wildlife recommendations) of Indian tribes affected by the project."

(TITLE 16-CONSERVATION, CHAPTER 12-FEDERAL REGULATION AND DEVELOPMENT OF POWER, SUBCHAPTER I-REGULATION OF THE DEVELOPMENT OF WATER POWER AND RESOURCES, Sec. 803 -Conditions of license generally)

This study aims to provide information on improving the flood management benefits of Oroville Project, in support of the relicensing process. It addresses the following specific issues identified in the scoping process:

- **Issue Statement No. E5:** Impact of flood releases on Lake Oroville dam (including need for access to north side of dam) and downstream facilities including downstream levee stability and potential for ameliorating downstream flooding through coordinated releases with other water storage facilities. Consider past floods, improvements in channel carrying capacities, need for more storage (e.g., installing Obermeyer gates on the emergency spillway ogee), operational changes, early warning system for downstream releases, and updating of flood operation manual.

There are a number of studies either completed long ago, recently or in progress about the Feather River Flood issues. This includes The Comprehensive Study, The Yuba Feather Flood Protection Program, The Sutter Feasibility Study and other studies by USACE. To address the issues raised in the scoping process, this information needs to be compiled, evaluated and possibly updated and refined. In particular, the study would:

- Document and compile the current information on Feather River Flood issues in one report; and,
- Update, any studies, if necessitated by better information on characteristics of the Feather River Basin, topographic maps and advanced software, and any changes proposed during the relicensing process.

Analyze and evaluate the effects of changes in operation of Oroville dam and construction of new and/or alteration of existing facilities for flood control.

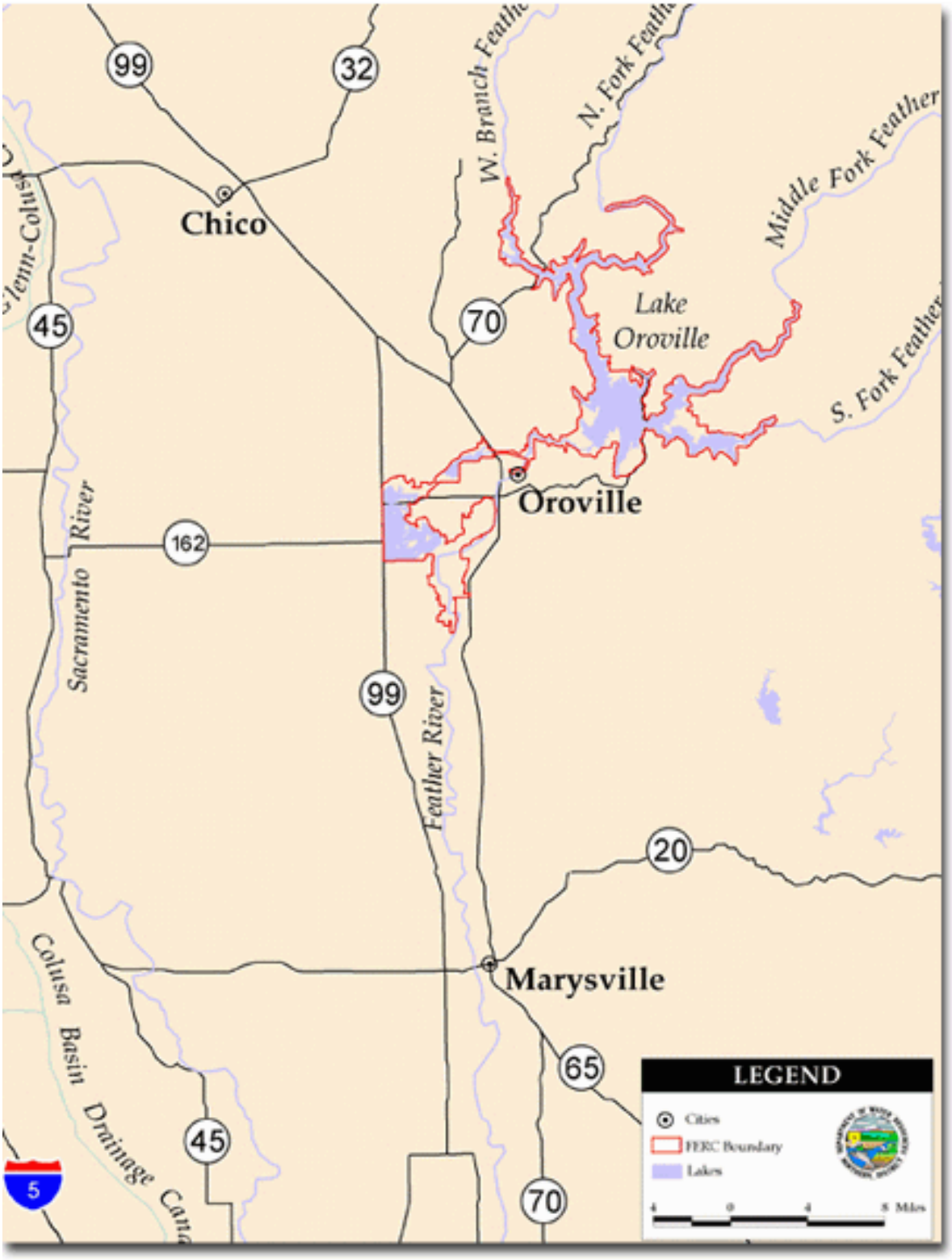
Issues Addressed

- EE11—coordinate releases with other water storage facilities for flood release
- EE17—update flood operation manual
- EE19—early warning system for downstream releases
- EE21—outflow impacts to downstream flood risk (levee stability) COE?
- EE22—stability of Oroville levee system through low flow section and effects of high flow
- EE23—evaluate channel capacities and potential need for more storage / flood protection engineering and operations deflection into levees by gravel bars

- EE47—in the FERC Part 12 guidelines, the Probable Maximum Flood (PMF) is to be examined after each major flood event. The Feather River has had two major flood events since 1971; once in February 1986 and again in January 1997. The FERC Part 12 regulation guidelines also state that when new Hydro-meteorological Reports (HMR's) are issued, the PMF is to be re-examined. New HMR's (HMR 58 & 59) were issued in 1999, thus precipitating the Oroville 2100 project to be re-examined in light of the new data. I think that this has been done for the 2100 project in the last Part 12 inspection and the Work Group should be given the correct data. If not done, the question is why not?
- EE51—provide the Work Group with the study data done on installing Obermeyer Gates on the emergency spillway ogee to raise the reservoir elevation in a major flood runoff event. What is the probability of this installation?
- EE52—provide the workgroup with the latest PMF, HMR, and PMP (probable maximum precipitation) data?
- EE53—when was the last "Inflow Design Flood" (IDF) study done and was it done on current data?
- EE56—prepare flood inundation maps for a 1997(?) worse case with 300,000 cfs coming out of the dam's normal and emergency spillways. In 1997, it is believed that Oroville storage was almost to a point where the 300,000-cfs of inflow was going to pass through the reservoir. DWR was making plans to evacuate the power plant. The 300,000 would have topped the levees and put 10 feet of water into the town of Oroville.

4.0 Study Area

FERC Project 2100 Boundary and the Feather River upstream of the Oroville dam that forms Oroville Reservoir Watershed, and downstream to confluence with the Yuba River.


99
32
Chico
W. Branch Feathe
N. Fork Feathe
Middle Fork Feather
Lake
Oroville
S. Fork Feather
45
70
Oroville
162
Sacramento River
99
Feather River
20
Marysville
Colusa Basin Drainage Cana
65
45
5
70
LEGEND
Cities
FERC Boundary
Lakes
4 0 4 8 Miles

5.0 General Approach

The Issue Statement No. 5 refers to "downstream levee stability". Project Levees on Feather River are under the jurisdiction of the US Army Corps of Engineers. They would take the lead in any Project Levee improvement program.

The general approach of the study would be to:

- Evaluate and, if necessary, update existing studies to reflect current conditions, technology and information, including:
    - Estimating the storm precipitation
    - Estimating run off and flood routing
    - Inundation studies

- Identify and evaluate potential future alternatives regarding flood management, including:
    - Measures for advance information for inflow into Oroville reservoir
    - Structural modifications in the project facilities
    - Changes in the operations of dam

- Coordinate with and incorporate the results of relevant studies being done by other agencies as listed in Task 1, 2 and 3 in Section "Detailed Methodology and Analysis Procedures"

In general, opportunities and constraints for improving flood control and reducing downstream flood hazard will be examined. Particular emphasis will be placed on identifying and evaluating reliable flood hazard reduction strategies that have minimal impact on water supply and hydropower production.

Regulatory and/or institutional opportunities to reduce flood hazard under the existing flow regime would be considered. Approaches to be examined, developed in consultation with DWR, YCWA, and the COE may include the following:

- Modification of current operating rules to improve flood control performance with the current flood control storage amounts.
- Modification of current operating rules and flood control storage amounts to improve flood control performance during a recurrence of the 1997 flood.
- The use of Forecast Based Operation of the reservoir. Temporary increases or decreases in the amount of flood control storage and flow conditioned on the predicted inflow, weather conditions and the watershed state.
- Strengthening regulatory control of land use.
- Modification of current notification procedures. Opportunities for improving existing communication and warning systems and procedures in the event of a flood will be identified.

This study would avoid duplication of the work being done on any of the above items studied by other agency. Rather, it would cooperate with those efforts and use their results.

Task 1— Review Existing or In-progress Literature on Feather River Floods

In this task, the following existing reports would be reviewed:

- Oroville Dam-PMF (Probable Maximum Flood) Analysis 2001:
  DWR is in the final stages of completing an updated PMF analysis of Oroville Dam. The report would be issues by the end of 2001.

  This update is being done in accordance with the 1999 Director's Safety Review Board Recommendations No. 1. The PMF would be developed using HMR-58. It would be routed through the Oroville Lake and Flood Control Outlets, assuming a number of scenarios:

  - Full operation of all spillway gates
  - No-operation of one and two spillway gates
  - Minimum residual freeboard on Oroville dam, Bidwell and Lime saddle dams.

The elevation of Oroville Reservoir at the start of event is 848 feet. The analysis would consider the criteria set forth by the Report on Reservoir Regulation for Flood Control in 1970. "Releases from Oroville Dam are not to be increased more than 10,000 cfs nor decreased 5,000 cfs in any 2-hour period". This criterion is expected to have significant effect on reservoir water surface elevation.

- Inundation Studies:
  - Flood Inundation Study of the Feather River by DWR- 1998
  - Oroville Dam Inundation Maps by the US Army Corps of Engineers-2000
  - Feather River Backwater Analysis by Corps of Engineers 2001
  - DWR completed the 1998 study to assess the affect of flood releases from Oroville Dam. Inundation maps showing the extent of flooding were prepared. The maps delineated the boundaries of flood flows of 150,000 cfs (Standard Project Flood Release) and 400,000 cfs.
  - As a check of computations, the surveyed high water elevations during the flood of January 1997 were compared with the computed profile of the same discharge.

  Major features and assumptions of the study were:

  - Only two cross sections, below Oro Dam Blvd. were actually surveyed. Other flood plain geometry and cross sections were determined from USGS Quadrangle maps, previous USGS studies, and photogrammetric surveys. Channel depth was determined from field inspection and from a 1994 fish habitat study performed by DWR.
  - Flow was assumed steady between cross sections, gradually varied, and one-dimensional.
  - Levees: All existing levees are intact for flows up to 150,000 cfs.

  The study found that flows greater than 150,000 cfs encroach the west levee free board just downstream of East Gridley Road at less than 3-feet from the top of the levee. The capacity of the west levee near the town of Gridley is approximately 270,000 cfs.

- **Oroville Dam Inundation Maps by the US Army Corps of Engineers-2000**
  The Corps of Engineers prepared the Inundation Map in October 2000 at the request of DWR. This latest map is a part of the Emergency Action Plan for Oroville facilities.

- **Feather River Backwater Analysis by Corps of Engineers 2001**
  US Army Corps of Engineers is doing a study of the water surface profiles in the Feather River (from Oroville Dam to the Confluence of Feather River with the Sacramento River) during a 10, 50, 100 and 500-year flood. It also includes a Floodway Analysis of the 100-year flood. It is not an inundation study for Dam Break flood, but a statistical flood analysis study.

  The study is expected to be complete shortly, although firm schedule is not available.

- **Forecast Based Operation (Advance Release) of Oroville Dam**
  US Army Corps of Engineers and the US Bureau of Reclamation are in the process of developing a Flood Management Plan for American River using this concept. The Water Resources Development Act of 1999 directed the Corps and the Bureau to update the Flood Management Plan to reflect the improved weather forecasts based on the Advanced Hydrologic Prediction System of the National Weather Service. Corps is leading a multi agency team working on this plan.

  The Comprehensive Study, lead by US Army Corps of Engineers, and the Reclamation Board of the State of California as well as the Yuba-Feather Flood Protection Program lead by Yuba County Water Agency would evaluate the use of this concept for Oroville Dam operations to improve flood protection. The Comprehensive Study is scheduled for completion in early 2002, however the completion of Yuba-Feather Flood Protection Program is not firm.

  The innovative program relies upon more on the best available data and less on rule curve. The methodology allows advance releases based on:

  - Inflow forecast by measuring precipitation in the watershed.
  - Using uncertainty estimates along with best estimates of forecast hydrograph.

  Inflow forecasts by measuring the precipitation in the watershed may advance releases by several hours. Releases may also be based on precipitation forecasts by observing incoming storms, which could allow for releases several days in advance. Reservoir elevation, inflow and outflow conditions preceding a major storm are major factor in determining the size of advance release.

  The effect of advance releases is to create additional flood space in the reservoir and are to be used for rare storms. The size of advance release would have economic effects, therefore a range of advance release sizes would be studied.

- **Review Emergency Action Plan (EAP) for Oroville Facilities**
  The primary purpose of an Emergency Action Plan (EAP) is to provide operating and mobilization and notification procedures to be followed in case of an emergency. An emergency is defined as an impending or actual sudden release of water at the project caused by natural disaster (i.e. flood or earthquake), accident, or failure of project works. The EAP can be used to provide a useful public

service by informing downstream entities of an impending flood condition when the dam is not in danger of failing and large spillway releases are expected.

Each licensee for a constructed project is required to prepare an EAP. DWR has on file with the FERC an Emergency Action Plan for the Oroville Facilities P-2100. DWR prepares updates as required by the FERC. Information used to prepare the EAP includes flood inundation maps and identification of life and property downstream that could be affected by a flood event or emergency, including a failure of the dam under a PMF event and a sunny day break under normal conditions.

The EAP will be reviewed to identify any improvements that arise as a result of the relicensing analysis.

Task 2—Update Studies

This task would be carried out if the review of the above (existing and in-progress) studies shows that current information would significantly change the conclusions of these studies.

- **Oroville Dam PMF Analysis Study**
  The type of soil cover in a watershed basin directly affects the run off its characteristics. This information was previously determined in an approximate manner. However, as a part of relicensing, DWR has Geographic Information System database that includes more detailed information on soil cover. The impact of this information on the storm run off would be evaluated. If this were found significant, the study would be updated.

- **Flood Inundation Maps of the Feather River**
  The 100-year flood inundation maps would be updated if required by any changes to the project facilities, operations or the flood plain resulting from the relicensing process.

- **Forecast Based Operation of Oroville Dam**
  If the review of Flood Management Plan for American River, and Sacramento and San Joaquin River Basins, The Comprehensive Study, and the Yuba-Feather Flood Protection Program shows that additional local or site specific factors would not have significant impact on the conclusions, no update would be necessary. The results would be directly incorporated into the report. Otherwise, Forecast Based Operation of the Oroville Reservoir would be revisited.

Task 3—Coordinate and Cooperate with Ongoing Studies by Other Agencies

Potential Future Update to Flood Operations Manual by USACE. Flood Operations Manual is in the jurisdiction of USACE. It is possible that in the light of various flood control studies about Oroville Dam, and Folsom Dam, the Corps would make changes in the Flood Operations Manual. It is not a study that DWR would undertake. It is listed here simply as a possible that might impact the flood protection provided by Oroville Dam.
There are three major studies by other agencies, currently underway, which would affect Oroville Facilities Flood Control Operations as discussed below:

- **Yuba-Feather Supplemental Flood Control Project**

After the 1997 floods, Yuba County Water Agency initiated a seven-phase program (Supplemental Flood Control Program on the Yuba River)) to provide flood control on Yuba River. However the passage of Water Act 2000 (Yuba-Feather Flood Protection Program) has authorized immediate funds for flood control on Yuba and Feather rivers. Thus the Yuba County Water Agency has begun implementation of the Yuba-Feather Supplemental Flood Control Project. The schedule of the Y-FSFCP is "as soon as possible".

The purpose of Y-FSFCP is "to define and implement, as soon as possible, a cost effective, practicable program within the budget of the Yuba-Feather Flood Protection Program to provide the greatest possible increment of protection against flooding from Yuba and Feather Rivers." The project has three potential elements that involve Oroville Facilities:

- **Lake Oroville Enlargement.** Modifications to the emergency spillway to temporarily raise flood levels by 10 to 15 ft. Modifications include inflatable gates, fuse gates, or an inflatable dam on top of the emergency spillway.

- **Thermalito Afterbay Emergency Re-Operation:** Operational storage would be incorporated into flood operations by evacuating in advance of a forecast major storm event. Structural changes would not be needed.

- **Forecast Based Operation of Oroville Dam:** Utilizing National Weather Service Forecasts up to 3 days in advance of actual flows, the reservoir would be drawn down to create additional flood space.

The results of these three program elements would directly affect this study and the information developed regarding these elements would be considered in this study.

- **Sacramento and San Joaquin River Basins, Comprehensive Study**
  The Comprehensive Study will identify problems and opportunities, set planning objectives and priorities, and develop potential measures to address flood damage reduction and ecosystem restoration. The study will examine a full range of structural and nonstructural measures and strategies to ultimately lead to a new master plan for flood management for the Sacramento and San Joaquin River systems.
  The study is lead by US Army Corps of Engineers, and the Reclamation Board of the State of California. The four-year Comprehensive Study has been divided into two phases. Phase I was 18 months long and concluded with preparation of an Interim Report in April 1999. Phase II, now underway, includes evaluation of alternatives and preparation of master plans and associated Programmatic EIS/EIR documentation.

  The study will conclude in 2002.

- **Sutter County Feasibility Study**
  On September 12, 2001, the COE published a Notice of Intent to Prepare a Joint Environmental Impact Statement (EIS) and Environmental Impact Report (EIR) for the Sutter County Feasibility

Study, Sutter County, CA. The draft EIS/EIR is scheduled to be available for public review and comment late in calendar year 2002.

The action taken is a feasibility investigation to:

- Address improvements for the existing flood management systems
- Investigate additional areas of flood protection for Sutter County
- Integrate system restoration

The study area is located within the boundaries of the Sacramento River Flood Control Project in Sutter County and includes the Sacramento, Feather, and Bear Rivers; Natomas Cross Canal; Sutter and Tisdale Bypasses; Wadsworth Canal; Yuba City and communities of Live Oak, Meridian, Robbins, Pleasant Grove, and Nicolaus.

Task 4—Report

A report will be prepared identifying and analyzing potential opportunities for future improvements in Flood Management summarizing the work completed in each task.

6.0 Results and Products/Deliverables

Results

The products of the Flood Management Study will include:

- Mapping of the flood plain under current operations showing areas inundated by floods of various flows under present conditions
- Estimate of the 100-year water surface profile between Oroville Dam and the confluence of the Feather and Yuba Rivers.
- Identification of potential measures (structural and non structural) to improve the flood protection provided by Oroville facilities.
- Quantitative and qualitative effects of the flood protection measures in the following areas:
    - Engineering
    - Economics
    - Environmental Impacts
    - Recreation
    - Regulatory Environment
    - Water Supply

Products/Deliverables

The product of this study will be a comprehensive report on the evaluation of various flood protection measures and related graphics and maps.

7.0 Coordination and Implementation Strategy

Coordination with Other Resource Areas/Studies

This study will require coordination with other work groups; specifically:

- Cultural Resources Work Group – Effect on properties eligible for listing on the National Register.
- Recreation and Socioeconomic Work Group.- Impact on the proposed recreation enhancements, including the proposed Riverbend Park. Potential effects on downstream property under any proposed modifications to current practice.
- Land Use, Land Management and Aesthetics Work Group. –Role of improvements in zoning and other planning activities at the local level.
- Environmental Work Group.- ESA considerations

Organizations within DWR involved in the study:

- DWR-Division of Engineering
- DWR-Division of Operations and Maintenance
- DWR-Division of Flood Management

Agencies with related activities:

- US Army, Corps of Engineers
- US Bureau of Reclamation
- US Geological Survey
- Federal Emergency Management Agency
- Yuba County Water Agency
- Butte County
- City of Oroville
- City of Yuba City
- Sutter County
- US Fish & Wildlife Service and National Marine Fisheries Service

Study Plan Tracking/Regulatory Compliance Requirements

The relicensing process requires that issues identified in the scoping process be addressed. This study complies with the relicensing process by addressing Issue Statement No. E5: "Impact of flood releases on Lake Oroville dam (including need for access to north side of dam) and downstream facilities including downstream levee stability and potential for ameliorating downstream flooding through coordinated releases with other water storage facilities. Consider past floods, improvements in channel carrying capacities, need for more storage (e.g., installing Obermeyer gates on the emergency spillway ogee), operational changes, early warning system for downstream releases, and updating of flood operation manual."